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NEIL F. HARTIGAN
ATTORNEY GENERAL
STATE OF ILLINOIS

Writer's Direct Dial Number
(312) 793- 2512

September 28, 1983

Dr. Emilio Sturino
Hazleton/Raltech Labs
3301 Kinsmas Blvd.
Madison, WI 57304

Re: Request For Proposal:
Bench Scale Testing of Detoxification
Of Cyanide Contaminated Chips

Dear Dr. Sturino:

From our recent telephone conversation, I understand that you have the expertise and lab facilities necessary to perform a bench scale test on the technical feasibility of testing cyanide contaminated film chips using a caustic soda wash followed by sodium hypochlorite treatment.

I am requesting that you submit a formal proposal detailing specific procedures and methods along with a cost estimate. Please indicate the time necessary to complete the testing and issue a report of your findings. Per our conversation, attached is a description of the objectives and purpose of the testing and a general draft outline to assist you in forming your more detailed proposal.

If you have any questions or suggestions as to changes or modifications please feel free to contact me or Howard Chinn (312/793-2515). Please reply as expeditiously as possible.

Very truly yours,

Tom Borecki

THOMAS BORECKI, ENGINEER
Environmental Control Division
160 North La Salle, Room 900
Chicago, IL 60601

TB:ib
Encl.

DRAFT

BENCH SCALE TEST

The purpose of this bench scale test is to determine the technical feasibility of detoxification of cyanide contaminated film chips by chemical treatment using a caustic soda rinse followed by sodium hypochlorite treatment of the rinse water. This test should be designed and performed to yield guidance data to aid in an assessment as to whether pilot or full scale testing is warranted. The critical parameters to be examined (using Standard Methods where applicable) include:

1. Caustic concentrations and feed rate
2. Sodium Hypochlorite concentrations and feed rate
3. Reaction times
4. Temperature (i.e. hot v. ambient caustic wash)
5. Dewatering characteristics of chips by gravity draining
6. Starting and final cyanide (Both Total and Amenable to chlorination), cyanate, and metals (Iron, Silver, etc.) concentrations
7. pH and oxidation/reduction potential monitoring and recording
8. Final effluent quality including pH, suspended solids, cyanide, and metals.

BASIC OUTLINE

This basic outline should be modified and expanded to detail the exact step by step methods and procedures to be followed and should be provided along with an exact cost estimate.

A) Test batches of chips for starting cyanide, cyanate, and metals concentrations.

B) Determine dewatering characteristics of soaked chips by gravity draining using 1/8" - 1/16" screen.

C) A set of tests to determine cyanide removal efficiency of caustic wash/soak. Vary the amount and concentration of caustic used to soak chips as well as mixing time, (suggest 5 min., 15 min., 30 min.)

D) Drain caustic soaked chips as per results from Step B. Test chips for final cyanide, cyanate, and metals concentrations. Test caustic wash for cyanide, cyanate and metals concentrations.

E) It may be advisable to perform a simple water rinse step immediately following the caustic wash/soak step. Add this rinse water to caustic wash water and proceed to Step F.

F) A set of tests to determine cyanide destruction efficiency under conditions varying the amount and concentration of sodium hypochlorite as well as mixing time (suggest 1/2 hr., 1hr., 2 hr.).

G) Test treated wash water for cyanide, total suspended solids, pH, metals. (Attached are discharge limits to sewers which effluent from a pilot or full scale process might be required to meet.)

APPENDIX B
to the
SEWAGE AND WASTE CONTROL ORDINANCE

DISCHARGES TO AND POLLUTION OF SEWERAGE SYSTEMS

The following are the maximum concentrations acceptable for discharge of sewage, industrial wastes, or other wastes into sewerage systems under the jurisdiction of The Metropolitan Sanitary District of Greater Chicago at any time:

WASTE OR CHEMICAL	CONCENTRATION (mg/l)
Boron	1.0
Cadmium	2.0
Chromium (total)	25.0
Chromium (hexavalent)	10.0
Copper	3.0
Cyanide (total)	10.0
Cyanide (readily released at 150° F and pH 4.5)	2.0
Fats, Oils or Greases (FOG) (Total)	100.0
Iron	50.0
Lead	0.5
Mercury	0.0005
Nickel	10.0
Zinc	15.0

pH Range - Not lower than 4.5 or greater than 10.0

Temperatures of liquids or vapors at point of entrance to a public sewer shall not exceed 150°F.

ILLINOIS INSTITUTE OF TECHNOLOGY

Armour College of Engineering
Pritzker Department of Environmental Engineering

October 6, 1983

Mr. Thomas Borecki
Environmental Engineer
Office of the Illinois Attorney General
160 North LaSalle Street
Chicago, IL 60601

Dear Mr. Borecki:

In accordance with your request for proposal dated September 28, 1983, regarding detoxification of cyanide contaminated film chips, I am pleased to transmit the attached proposal. I would appreciate, as indicated, that the work authored could be completed within a ten week period, and with time allowed for start-up and report preparation, a final report could be transmitted to you within 14 weeks from approval of this proposal.

Should you have any questions, please feel free to contact me.

Yours truly,

Charles N. Haas, Ph.D.
Associate Professor

Approved,

Geoffrey T. Higgins,
Dean, School of Advanced Studies

CNH/at

Attachment

IIT Center Chicago, Illinois 60616 (312) 567-3535

DETOXIFICATION OF CYANIDE CONTAMINATED FILM CHIPS

OBJECTIVE

The aim of this study is to determine whether a preliminary caustic treatment will improve the treatability of cyanide contaminated film chips by chlorine oxidation.

MATERIALS AND METHODS

Film chip waste will be supplied and delivered to IIT by the Office of the Attorney General.

Six random samples of the delivered waste will be used to study dewatering properties. Samples will be placed above a coarse screen (1/16 - 1/8") and the volume of water drained as a function of time will be measured. The initial and final wet weighs of the film chips will be measured.

At a sufficiently lag time (eg. 1-2 hrs) after the bulk of readily mobile water has been lost, the six liquid samples will be collected and measured for cyanides (total and amenable to chlorination), silver, iron, and cyanates. The drained film chips will also be analysed for these constituents.

The major phase of this project will involve studies on alkaline pretreatment of film chips. The chips will be drained, and a known wet weight of film chips will be added to deionized water containing a known concentration of NaOH. At various times, the supernate will be decanted for analysis for cyanides (total and amenable), cyanates, iron and silver. In addition, the initial and final pH will be measured.

These experiments will be conducted using distilled water alone, and four doses of caustic, with the greatest dose sufficient to raise the final pH to 12. Times will range between 5 minutes and 2 hours. The conditions of mixing will be held constant (eg. 100 rpm in a multiple place stirring apparatus). Experiments will be conducted using two temperatures, ambient and leaching solution initially heated to 35°C.

This phase of the study will result in the determination of conditions maximizing the extent of cyanide leaching from the film chip wastes.

The third and final phase of this study will determine the amenability of the spent, cyanide-containing, alkaline leach solution to hypochlorite oxidation. Using the optimum leaching conditions determined in the previous phase, contaminated leachant will be produced. The leached film chips will be rinsed with a volume of water equal to the volume of leach solution. The rinse water, spent leachant, and initially decated liquids will be combined.

This combined liquor will be adjusted to pH 10.5 (which has been reported to be optimal for CN-oxidation) and with 4 doses of sodium hypochlorite ranging up to 300% of the stoichiometric dose for complete cyanide oxidation. After mixing and contact for ½, 1 and 2 hrs, the treated solutions will be analysed for cyanides, cyanate, silver and iron. At the end of 2 hours, the treated solutions will be analysed for free and total chlorine.

Should single stage chlorination not be sufficient to produce complete oxidation to CO_2 and N_2, a two step chlorination process will be examined. The pH will be initially adjusted to 10.5, and following a 1 hour time of contact, the pH will be adjusted to 8.5 to permit more facile oxidation of cyanates. If necessary, additional chlorine will be added, and following a second 1 hour contact, parameters noted above will be determined.

Analytical Methods

Cyanide (total and amenable) will be determined using the distillation pretreatment followed by electrode. Cyanate will be determined using the ammonia electrode procedure in Standard Methods for the Analysis of Water and Wastewater. Metals (iron and silver) will be determined using atomic absorption spectrophotometry, if practicable using flame atomization, otherwise using flameless graphite furnace atomization. In the presence of solids, acid digestion will be utilized, and in all metals analyses the method of standard additions will be employed.

Chlorine residuals will be determined using the reverse iodometric titration procedure for total residual and the amperometric method for free residual. All other analyses will be calculated using the procedures in Standard Methods.

FINAL PRODUCT

The final product of this study will be a conclusion as to the efficiency of alkaline leaching followed by chlorination for the destruction of cyanides present in the film chip waste. Additional information on the suitability of the liquid and solid effluents for disposal vis a vis other pollutants (Fe, Ag) will also be generated.

BUDGET AND TIME SCHEDULE

The authored effort to be conducted over a 10 week period will require the following budget, however the Principal Investigator shall return sale budgeting authority within the stated overall project costs.

Personnel	
Students, 450 hours @ $5.25/hr	$2362
PI, 10% for 10 weeks	900
Secretarial	300
Technician	250
Total Personnel	$3812
Materials	1700
Equipment (cyanide electrode, cyanide stills, silver AA lamp)	1200
Miscellaneous (phone, photocopying)	300
	$7012
Fringe Benefits (20% Non-Student)	290
Modified Total Direct Costs	7302
Indirect Costs (60%)	3661
Total Project Costs	$ 10,963

The estimated time required for completion of this project will be consumed according to the following schedule:

WEEK 1 Notification of award, order supplies, define protocol

WEEK 3 Start experimental work

WEEK 4 Dewatering and waste characterization

WEEK 5-9 Leaching studies

WEEK 10-13 - Chlorination studies

WEEK 14 Report delivered

Personnel and Facilities

The studies will be conducted in the laboratories of the Pritzker Department of Environmental Engineering at IIT. Dr. Charles N. Haas, Associate Professor of Environmental Engineering, will serve as Principal Investigator. He has extensive experience in the areas of chlorination, trace metal chemistry, and hazardous waste treatment. His curriculum vitae is attached. It is anticipated that he will spend 4 hours per week in the management of this project.

The experimental work will be executed under Dr. Haas' direction by two hourly students, each employed for 20 hours/week. It is anticipated that these students will be graduate students in Environmental Engineering at IIT.

Facilities available within the department of Environmental Engineering for use in this study include atomic absorption spectrophotometers (for metal analyses), chlorine analyses, specific ion electrodes, and meters, and general wet chemical analysis equipment.

RESUME

Name: Charles N. Haas

Present Position: Associate Professor
Pritzker Dept. of Environmental Engineering
Illinois Institute of Technology
Chicago, IL 60616, Tel: 312/567-3537

Social Security Number: non-responsive

Date of Birth: non-responsive

Place of Birth: non-responsive

Citizenship: U.S.A.

Education: B.S. (Biology), Illinois Institute of Technology, 1973.

M.S., Illinois Institute of Technology, Environmental Engineering, 1974.

Ph.D., University of Illinois, Urbana, Illinois, Environmental Engineering in the Department of Civil Engineering, 1978.

Professional Experience:

1983-Current: Associate Professor, Illinois Institute of Technology.

1981-1983: Assistant Professor, Illinois Institute of Technology.

1978-1981: Assistant Professor of Environmental Engineering in the Department of Chemical and Environmental Engineering, Rensselaer Polytechnic Institute; taught undergraduate courses in general and environmental engineering and graduate courses in environmental engineering which were also taken by students majoring in chemical engineering; directed M.S. and M. Eng students; developed and conducted research in water and wastewater treatment, microbiology and disinfection, and in hazardous waste treatment.

1979-1981: Acting Director of Environmental Engineering Programs at R.P.I.; Responsible to the Acting Chairman for all aspects of the program; advised 60 part-time graduate students; managed the graduate student recruitment and admissions process; member of the departmental and campus-wide Graduate Committees.

Professional Society Memberships:

Water Pollution Control Federation
International Association on Water Pollution Research and Control
American Water Works Association
American Society of Civil Engineers
American Institute of Chemical Engineers
American Society for Microbiology
American Chemical Society
American Association for the Advancement of Sciences
Association of Environmental Engineering Professors
Sigma Xi
Western Society of Engineers
American Society for Engineering Education

Other Professional Development Activities:

Participant, NATO Advanced Studies Institute on Mass Transfer and Kinetics of ION Exchange, Maratea, Italy, June 1982. (Received NSF International Travel Grant for attendance).

Visiting Scientist, Italian National Research Council, Institute for Water Research, Bari, Italy, June 1982.

Contribution to Teaching:

a. Summary of Experience at Rensselaer Polytechnic Institute

During 3-1/2 years at R.P.I., 8 courses were taught, and are summarized below with results of course evaluations for each course. In particular, during this time, I was responsible for development of three new courses at the graduate level--Advanced Aquatic Chemistry, Biological Treatment Processes, and a summer course in Hazardous Waste Treatment, and also taught a sophmore level course in Thermodynamics which was required of all engineering majors.

Course	Semester	# Enrolled	# Responses	Course (4 point max.)	Instructor
ENVE LAB II	Spring 78	29	21	2.67	2.70
Unit Processes	Spring 78	27	23	3.17	2.74
Chemistry for Env. Eng.	Fall 78	4	4	3.25	3.33
Adv. Aquatic Chemistry	Fall 78	6	6	3.67	3.50
Env. Eng. Lab. I	Fall 78	20	12	2.73	2.55
Unit Processes	Spring 79	29	25	3.50	3.58
Thermodynamics	Spring 79	47	24	2.33	3.04
Adv. Aquatic Chemistry	Spring 80	4	4	3.75	4.00
Biol. Tmt.	Spring 80	19	18	3.39	3.59
Unit Ops.	Spring 80	21	21	2.82	2.94
Biol. Tmt.	Spring 81	16	not available		

b. Summary of Experiences at I.I.T.

Course	Semester	# Enrolled	# Responses	Course	Instructor
ENVE 501	Fall 1981	24	20	3.94	4.00
ENVE 402	Fall 1981	5	5	4.20	4.40
ENVE 513	Spring 1982	8	7	4.71	4.82
ENVE 541	Spring 1982	10	10	4.30	4.44
ENVE 501	Fall 1982	6	6	3.70	4.30
ENVE 513	Spring 1983	4	4	5.00	4.75
ENVE 561	Spring 1983	8	7	4.10	4.50

c. Advising of Students

At R.P.I., served as academic advisor to approximately 3-10 undergraduate students and 5 graduate students per year, and during the period of service as Acting Director, 60 part-time graduate students.

Year	Degree	Student	Title
1979	M. Eng.	P.A. Sajous	Oxygen Uptake Rate as a Control of Activated Sludge Process
1979	M. Eng.	E.C. Morrison	Development and Description of Altered Sensitivity to Chlorine in E. coli.
1980	M.S.	P.A. Hughes	Laboratory Investigation of the Activated Sludge Process with Alum Addition for the Removal of Trace Metals.
1980	M.S.	C.A. Weitz, Jr.	Ultraviolet Reactor Design Using Hydraulic Parameters
1982	M. Eng.	M.A. Zapkin	Inactivation of Escherichia coli by Chlorine in the Presence of Various Additives.
1983	M.S.	M.S. Paller	Investigations of Microbial Activity on GAC Filters

Students Advised at IIT:

1981	M.S.	L.M. Mele*	Surface Water Hydrology of Coal Refuse Disposal Sites
1982	M.S.	R. Garunas*	Acid Waste Gas Biodesulfurization: An Alternative to Chemical Sulfur Recovery Processes.
1982	M.S.	K.A. Lavelle*	Desulfobacter Biocatalyzed Reduction of Gypsum Wastes: Applications to Phosphoric Acid Manufacturing.
1983	M.S.	S.B. Karra	Kinetic Limitations on the Recovery of Metals From Wastewater by Precipitation.

* Co-Advisor

Student Research In Progress

Degree	Student	Topic
M.S.	Medaras Keralius	Enhancement of Chlorine Disinfection Efficiency by Potassium and Lithium.
M.S.	Kamel Khater	Sensitivity of Protozoa to Combined Chlorine.
M.S.	Robert Renaud	Investigation of Thiosulfate and other Dechlorinating Agents.
M.S.	Juvenal Gonzalez	Sodium Enhancement of Cholorination in the presence of chlorine Demand.
M.S.	Alan Wojtas	Sensitivity of Protozoa to Free Chlorine.
M.S.	Paul Bitter	Limiting Nutrients for Bacteria in Drinking Water.
M.S.	Thomas Jamrock	Analysis of the Hazardous Waste Extraction Procedure test.
M.S.	Manickam Annamali	Dynamic Wastewater Chlorination Modeling.
M.S.	Noah Horowitz	Chemical Alterations of Metal Bioavailability.
M.S.	John Muskovitz	Leachability of Metal - Starch-Xanthate Sludges.
M.S.	Brian Kaplan	Humic Effects on Vapor-Liquid Mass Transfer of Organic Micropollutants.

2. Research and Scholarly Work

a. Research Projects

Rensselaer Polytechnic Institute

Co-principal Investigator "Hazardous Waste Processing and Disposal Practices--Best Technology." New York State Environmental Facilities Corporation (1979 for $25,000).

Co-principal Investigator "The Potential for the Application of Resource Recovery Practices in the Hazardous Waste Processing and Disposal Industry." New York State Environmental Facilities Corporation (1979 for $25,000).

Principal Investigator "Microbiological Alterations in Water Quality in Distribution Systems and Granular Activated Carbon." U.S. Environmental Protection Agency (1980-1982 for $113,000).

Illinois Institute of Technology

Co-principal Investigator "Evaluation of High-Performance Phosphorous Control POTW's in the Great Lakes Basin." U.S. Environmental Protection Agency (1981-1982 for $88,850).

Principal Investigator "Preparation of a Chapter on Chlorination-Dechlorination and Miscellaneous Halogens." U.S. Environmental Protection Agency via a subcontract from Oklahoma State University (1982-1985 for $82,000).

Principal Investigator "Metal Speciation and Separation." U.S. Environmental Protection Agency--Industrial Waste Elimination Research Center (1982-1983 for $119,000).

Principal Investigator "Wastewater Treatability Study." Modine Manufacturing Company (1982-1983 for $28,000).

Principal Investigator "Evaluation of Microbial Dynamics in the Calumet River and Downstream Waters." Metropolitan Sanitary District of Greater Chicago (1983-1984 for $16,800).

b. Review of Papers for Journals

Environmental Science and Technology
Journal of the Water Pollution Control Federation
Proceedings of the Water Chlorination Conference
Water, Air and Soil Pollution
Environmental Technology Letters
Water Research
Journal of the American Water Works Association

c. Review of Proposals

U.S. Environmental Protection Agency

d. Panels and Seminars Chaired

Organized and Chaired a Seminar on "Mode of Action of Halogen Disinfectants Used in Water and Wastewater Treatment" at the Annual Meeting of the American Society for Microbiology, Dallas, March, 1981.

Organized and Chaired a session on "Disinfection and Chemical Oxidation" at the Annual Meeting of the American Institute of Chemical Engineers, New Orleans, November, 1981.

Organized and Chaired a Session on "Potpourri: Industrial and Toxic Wastes" at the National Meeting of the American Institute of Chemical Engineers, Cleveland, August, 1982.

Organized and Co-Chaired a Session on "Recovery of Metal Values From Industrial Wastes" at the National Meeting of the American Institute of Chemical Engineers, Denver, August 1983.

e. Papers and Seminars Presented

1) "Amino Acids, Aquatic Bacteria and Diatoms: Possible Methods of Interaction." Presented at the 67th Annual Meeting of the Illinois State Academy of Sciences, Springfield, May, 1974.

2) "Physiological Alterations of Vegetative Microorganisms Resulting From Aqueous Chlorination." Presented at the Research Symposium during the 51st Annual Meeting of the Water Pollution Control Federation, Houston, October, 1978.

3) "Physiological Basis for Chlorination." Presented at a seminar of the Department of Civil Engineering, Syracuse University, Syracuse, NY, November, 1978.

4) "Mechanistic Aspects of Disinfection Kinetics." Presented at a seminar of the Department of Biomedical Engineering, Rensselaer Polytechnic Institute, Troy, NY, April, 1979.

5) "Mode of Microbial Inactivation by Chlorine." Presented at the National Conference on Environmental Engineering, American Society of Civil Engineers, San Francisco, July, 1979.

6) "Rational Analysis of Ultra-violet Disinfection Reactors." Presented at the National Conference on Environmental Engineering, American Society of Civil Engineers, San Francisco, July, 1979.

7) "Rational Analysis of Microbial Regrowth." Presented at the 178th National Meeting of the American Chemical Society, Division of Environmental Chemistry, Washington, DC, September, 1979.

8) "A Quantitative Model of Post-Disinfection Microbial Dynamics." Presented at the Research Symposium during the 52nd Annual Meeting of the Water Pollution Control Federation, Anaheim, October, 1979.

9) "Rational Approaches in the Analysis of Chemical Disinfection Kinetics," presented at the 179th National Meeting of the American Chemical Society, Division of Environmental Chemistry, Symposium on Chemistry and Chemical Analysis of Water/Wastewater Intended for Reuse, Houston, March, 1980.

10) "Repeated Exposure of E. coli to Free Chlorine: Production of Strains With Differential Resistance," presented at the 80th Annual Meeting of the American Society for Microbiology, Miami, May, 1980.

11) "Acid-Fast Bacteria and Yeast as Indicators of Disinfection Efficiency." Invited Presentation before the Interstate Seafood Seminar, Ocean City, MD, October, 1980.

12) "Theory of Alternate Disinfectants." Invited presentation at the Seminar on Current Topics in Water Supply, New York State Section of the American Water Works Association, Ossining, NY, November, 1980.

13) "The Practical Importance of Understanding Disinfection Mechanisms." Presented at the 81st Annual Meeting of the American Society for Microbiology, Dallas, March, 1981.

14) "Effects of Various Additions on the Inactivation of E. coli by Chlorine." Presented at the 81st Annual Meeting of the American Society for Microbiology, Dallas, March, 1981.

15) "Statistical Analysis of New York State Department of Environmental Conservation Lake George Bacteriological Sampling Data." Presented at the 1st Symposium of the Lake George Research Group, Lake George Association, Lake George, NY, April, 1981.

16) "Enhancement of Chlorine Inactivation of E. coli by Sodium Ions." Presented at the Fourth Water Chlorination Conference, Monterey, CA, October, 1981.

17) "Practical Considerations in the Use of Halogen Disinfectants," Invited presentation to the Second National Symposium on Municipal Wastewater Disinfection, sponsored by the U.S. Environmental Protection Agency, Orlando, January, 1982.

18) "Application of Ion Exchange to Recovery of Metals from Semiconductor Wastes." Presented at the NATO Advanced Studies Institute on Mass Transfer and Kinetics of Ion Exchange, Maratea, Italy, June, 1982.

19) "Estimation of Recreational Disease Reduction due to Disinfection: Illinois--A Case Study." Presented at the 55th Annual Conference of the Water Pollution Control Federation, St. Louis, October, 1982.

20) Seminars presented during a visit to the Italian National Research Council, Water Research Institute, Bari, Italy, June, 1982:
- "Rational Analysis of Chlorination Kinetics."
- "Use of Computer Equilibrium Models for Assessment of Industrial Waste Chemistry."
- "Novel Precipitation Processes for Metal Recovery from Semiconductor Wastes."
- "Application of Ion Exchange to Recovery of Metals from Semiconductor Wastes."
- "Solid Phase Differential Reactor Studies on Adsorption in Air and Water."

21) Seminar presented to the Italian National Research Council, Water Research Institute, Rome, Italy, June 1982:
- "Metal Removal and Recovery Processes: Experimental Results and Equilibrium Calculations."

22) "Relating Microbial Changes in Water Distribution to Physical-Chemical Water Quality." Presented at the 74th Annual Conference, Illinois Section, American Water Works Association, Chicago, March 1983.

23) "Direct Differential Reactor Studies of Adsorption from Liquid and Gaseous Solutions." Presented at the Engineering Foundation Conference on Fundamentals of Adsorption, Upper Bavaria, West Germany, May, 1983.

24) "Water and Wastewater Disinfection." Seminar presented at IBM Corp., East Fishkill, NY, June 1983.

25) "Kinetic Limitations on the Recovery of Metals From Wastewater by Precipitation." Presented at the American Institute of Chemical Engineers National Meeting, Denver, August 1983.

26) "Microbial Risk Assessment." Invited Presentation at the Water Pollution Control Federation, Preconference Workshop on Wastewater Disinfection Alternatives, Atlanta, October, 1983.

f. Publications

Peer-Reviewed Publications

1) "Oxygen Uptake Rate as an Activated Sludge Control Parameter." Journal of the Water Pollution Control Federation, 51, 938-943 (1979), Charles N. Haas.

2) "Physiological Alterations of Vegetative Microorganisms Resulting From Aqueous Chlorination." Journal of the Water Pollution Control Federation, 52, 1976-1989 (1980), C. N. Haas and R.S. Engelbrecht.

3) "Chlorine Dynamics During Inactivation of Coliforms, Acid-Fast Bacteria and Yeasts." Water Research, 14, 1749-1757 (1980), C.N. Haas and R.S. Engelbrecht.

4) "A Mechanistic Kinetic Model for Chlorine Disinfection." Environmental Science and Technology, 14, 339-340 (1980), C.N. Haas.

5) "Application of Predator--Prey Models to Disinfection." Journal of the Water Pollution Control Federation, 53, 378-386 (1981), C.N. Haas.

6) "Rational Approaches in the Analysis of Chemical Disinfection Kinetics." Chapter in W. Cooper (ed.) Chemistry in Water Reuse. Vol. 1, pp. 381-399. Ann Arbor Science Publishers, Inc. (1981), C.N. Haas.

7) "Practical Mixed Culture Processes." Advances in Fermentation Processes, 4, 1-29 (1980), C.N. Haas, H.R. Bungay and M.L. Bungay.

8) "Biological Process Diffusional Limitations." Journal of The Environmental Engineering Division, ASCE, 107, 269-273 (1981), C.N. Haas.

9) "Repeated Exposure of Escherichia coli to Free Chlorine: Production of Strains Possessing Altered Sensitivity." Water, Air and Soil Pollution, 16, 233-242 (1981), C.N. Haas and E.C. Morrison.

10) "Sodium Alterations of Chlorine Equilibria: Quantitative Description." Environmental Science and Technology, 15, 1243-1244 (1981) C.N. Haas.

11) "Evaluation of the m-SPC Method as a Substitute for the Standard Plate Count in Water Microbiology." Journal of the American Water Works Association, 74,322 (1982), C.N. Haas, M.A. Meyer and M.S. Paller.

12) "Enhancement of Chlorine Inactivation of E. coli by Sodium Ions." Water Chlorination: Environmental Impact and Health Effects, Volume 4, Book 2, pp 1087-96, edited by R.L. Jolley, Ann Arbor Science, (1983), C.N. Haas and M. Zapkin.

13) "The Utility of Endotoxins as a Surrogate Indicator in Potable Water Microbiology." Water Research, 17, 803-7 (1983), C.N. Haas, M.A. Meyer, M.S. Paller and M.A. Zapkin.

14) "The Ecology of Acid-Fast Organisms in Water Supply, Treatment, and Distribution Systems." Journal of the American Water Works Association, 75, 139 (1983), C.N. Haas, M.A. Meyer and Marc S. Paller.

15) Estimation of Risk Due to Low Doses of Microorganisms: A Comparison of Alternative Methodologies." American Journal of Epidemiology, in press, C.N. Haas.

16) "Effect of Effluent Disinfection on Risks of Viral Disease Transmission via Recreational Exposure." Journal of the Water Pollution Control Federation, 55, 1111-1116 (1983), C.N. Haas.

17) "Engineering at the Microorganism Scale." Advances in Fermentation Processes, 6, 149-173 (1983), H.R. Bungay, M.L. Bungay, and C.N. Haas.

18) "Microbial Dynamics in GAC Filtration of Potable Water." ASCE Journal of Environmental Engineering, 109, 956-61 (1983), C.N. Haas, M.A. Meyer and Marc S. Paller.

19) "Application of Ion Exchangers to Recovery of Metals From Semiconductor Wastes." Reactive Polymers, C.N. Haas and V. Tare, In press.

20) "Microbial Alterations in Water Distribution Systems and Their Relationship to Physical-Chemical Characteristics." Journal of the American Water Works Association, In press, C.N. Haas, M.A. Meyer and Marc S. Paller.

21) "Kinetics of Wastewater Chlorine Demand Exertion," Journal of the Water Pollution Control Federation, In press, C.N. Haas and S.B. Karra.

Papers Presently Under Review

1) "Evaluation of Segregation and Micromixing in Wastewater Treatment Processes" Submitted to Water Research, C.N. Haas.

2) Prediction of Multicomponent Ion Exchange Equilibria for Metal-Chelate Resin Reactors in Aqueous Systems." Submitted to Environmental Science and Technology, V. Tare and C.N. Haas.

3) "Kinetics of Metal Removal by Chelating Resin From a Complex Synthetic Wastewater." Submitted to Water Air & Soil Pollution, V. Tare, S.B. Karra and C.N. Haas.

4) "Removal of New Indicators of Disinfection Efficiency by Coagulation-Flocculation and Rapid Sand Filtration." Submitted to Journal of the American Water Works Association, C.N. Haas, B.F. Severin, D. Roy, R.S. Engelbrecht, and A. Lalchandani.

5) "Kinetic Limitations on the Selective Precipitation Treatment of Electronics Wastes." Submitted to Journal of the Water Pollution Control Federation, S.B. Karra, C.N. Haas, V. Tare and H.E. Allen.

Non-Reviewed Publications

1) "Chemical Basis for Interaction Between Aquatic Bacteria and Phytoplankton," Final Report to the National Science Foundation, Student Originated Studies Program (1973).

2) "Soluble Phase Chemistry of Trace Metal Transport Through Secondary Wastewater Treatment Systems," M.S. Thesis, Department of Environmental Engineering, Illinois Institute of Technology (1974).

3) "Heavy Metals Transport Through Municipal Sewage Treatment Plants." Proceedings, 2nd National Conference on Complete Water Reuse (1975). With J.W. Patterson and P. Shimada.

4) Discussion on "Temperature-Toxicity Model for Oil Refinery Waste." Journal of the Environmental Engineering Division, Proceedings ASCE, 101, 446 (1975).

5) "New Microbial Indicators of Disinfection Efficiency." Annual Report to the U.S. Army Medical Research and Development Command (1975). With R.S. Engelbrecht et al.

6) "Inactivation of New Indicators of Disinfection Efficiency, Part I. Free Available Chlorine Species Kinetics." Proceedings, 96th Annual Meeting, American Water Works Association (1976). With F. Surucu.

7) Discussion on "Cyanophage Analysis as a Biological Pollution Indicator--Bacterial and Viral." Journal of the Water Pollution Control Federation, 49, 1913 (1977).

8) "Acid-Fast Bacteria and Yeasts as Disinfection Indicators: Enumeration Methodology." Proceedings, 5th Water Quality Technology Conference, AWWA. (1977). With R.S. Engelbrecht.

9) "New Microbial Indicators of Disinfection Efficiency," U.S. EPA Environmental Protection Technology Series 600/2-77-052 (1977). With R.S. Engelbrecht et al.

10) "Mechanism of Inactivation of New Indicators of Disinfection Efficiency by Free Available Chlorine." Ph.D. Thesis, Department of Civil Engineering, University of Illinois at Urbana-Champaign (1978).

11) "Literature Review--Disinfection." Journal of the Water Pollution Control Federation, 50, 1134 (1978). With J. Gould.

12) "The Future of Chlorination." Rensselaer Fresh Water Institute at Lake George, Newsletter, Volume 8, #3 (1978).

13) "Acid-Fast Bacteria and Yeasts as Indicators of Disinfection Efficiency." Final Report to the U.S. Environmental Protection Agency, Report 600/2-79-091 with R.S. Engelbrecht et. al. (1979).

14) Discussion on "Effects of Chlorination on Differentiated Coliform Groups." Journal of the Water Pollution Control Federation, 51, 2961, (1979).

15) "Literature Review-Disinfection." Journal of the Water Pollution Control Federation, 51, 123 (1979), with J. Gould.

16) "Mode of Microbial Inactivation by Chlorine." Proceedings of the ASCE Environmental Engineering Specialty Conference, pp. 646-652, with R.S. Engelbrecht. (1979).

17) "Rational Analysis of Ultra-Violet Disinfection Reactors." Proceedings of the ASCE Environmental Engineering Specialty Conference, pp. 540-547, with G.P. Sakellaropoulos (1979).

18) Discussion on "Kinetics of Bacterial Deactivation with Chlorine." Journal of the Environmental Engineeering Division, ASCE, 105, 1198 (1979).

19) "Hazardous Waste Processing and Disposal Practices--Best Technology." Report to the New York State Environmental Facilities Corporation (1979) with W.W. Shuster, et. al.

20) "The Potential for the Application of Resource Recovery Practices in the Hazardous Waste Processing and Disposal Industry." Report to New York State Environmental Facilities Corporation (1979), with W.W. Shuster, et al.

21) "Literature Review-Disinfection." Journal of the Water Pollution Control Federation, 52, 1224 (1980), with J. Gould.

22) "Literature Review--Disinfection." Journal of the Water Pollution Control Federation, 53, 789 (1981), with J. Gould.

23) "What are Hazardous Wastes?" In R.L. Robbins (ed.), Limiting Liability for Hazardous Wastes, Chicago-Kent College of Law (1981).

24) "Technical Arguments Against the Adoption of Changes in the Illinois Wastewater Fecal Coliform Standards." Paper submitted to the Illinois Pollution Control Board (1981).

25) "Practical Considerations in the Use of Halogen Disinfectants." In A.D. Venosa (ed.), Proceedings of the Second National Symposium on Wastewater Disinfection, U.S. Environmental Protection Agency, in press.

26) "Literature Review--Disinfection." Journal of the Water Pollution Control Federation, 54,646 (1982). With J.J. McCreary.

27) "Evaluation of High-Performance Phosphorous Control POTW's in the Great Lakes Basin." Final Report to the US EPA. With J.W. Patterson et al. (1982).

28) "Management of Hazardous Wastes: An Illinois Perspective." Report to the Illinois Institute of Natural Resources, With J.W. Patterson (1982).

29) "Microbiological Alterations in Water Quality in Distribution Systems and Granular Activated Carbon." Final Report to the US EPA. With M.A. Meyer et al. (1983).

3. Contributions to the Educational and Intellectual Processes

Participated in RPI Environmental Engineering Curriculum Review, 1978-1979.

Assisted in the development of long and short range plans for the RPI Fresh Water Institute, 1978.

RPI Department of Chemical and Environmental Engineering Committee on Graduate Students, Member, 1978-1981.

Planning Committee for the UPS Conference, RPI Fresh Water Institute, 1979.

Member, RPI Biohazard Safety Committee, 1979-1981.

Advised RPI Safety Manager on Chemical Waste Disposal Practices, 1980-1981.

Member, IIT Graduate Study Committee, 1981-present.

Chairman, Departmental Faculty Search Committee, 1982-present.

4. Advancement of a Scholarly or Professional Discipline

a. Service to Learned or Professional Societies

American Society of Civil Engineers, Environmental Engineering Division
Member, Task Committee on Effluent Disinfection
1981-present.

American Water Works Association
Member, Research T & P Council Committee on Disinfection,
1980-present.
Member, Water Quality Division Committee on Organisms in Water,
1983-present.
Illinois Section Student Activities Committee,
Member, 1981-present
Chairman, 1983-present.

Association of Environmental Engineering Professors
Chairman, Committee to revise recruitment brochure,
1981-1983.

Water Pollution Control Federation
Member, Research Committee, 1978-1982.
Member, Research Committee Task Force on Toxic Substances,
1980-1982.
Member, Committee on Disinfection, 1980-present.
Vice-Chairman, 1982-present.
Member, Illinois Association Student Activities Committee,
1981-present.
Member, Technical Practices Committee Task Force on Disinfection,
1982-present.

b. Organization of Continuing Education Programs

Presented Invited Talks at the following programs:

Seminar on Current Topics in Water Supply, New York State Section of the American Water Works Association, Ossining, NY, November, 1980.

Limiting Liability for Hazardous Wastes, a continuing education program for lawyers, sponsored by the Chicago-Kent College of Law, Chicago, November, 1981, was also a member of the program Steering Committee.

WPCF Preconference Workshop on Wastewater Disinfection Alternatives, Atlanta, October 1983, Co-organizer and participant.

c. Consulting

Energy & Resource Recovery Corporation (Subsidiary of Alpha Portland Industries)--performed a regulatory analysis and preliminary feasibility study for the use of hazardous wastes and spent solvents as supplemental fuel in cement kilns, 1979.

New York State Department of Civil Service--served as a member of oral examination panels for the positions of Associate Sanitary Engineer and Associate Air Pollution Control Engineer, March thru May, 1981.

Patterson Associates, Inc.
--preparation of a state-of-the-art report on hazardous wastes in Illinois Institute of Natural Resources, May thru October, 1981.

--determination of hazardous waste production potential and management options for the forging industry, June thru October, 1981.

K.A. Steel Chemicals, Inc.--preparation of a technical document and testimony against the proposed changes of the Illinois wastewater fecal coliform standards, October, 1981 thru February, 1982.

PEER Consultants, Inc.--reviewed draft US EPA report entitled "User Guide for Evaluating Remedial Action Technologies." August, 1982.

Waste Management, Inc.--prepared testimony on the need for additional hazardous waste disposal capacity in Will County, Illinois, October 1982.

Katz, Friedman, Schur & Eagle/United Auto Workers--evaluation of technical documents relating to environmental impact of cooling water discharge at Quad Cities/Cordova Generating Station, June 1983.

d. Membership in Advisory Bodies

External thesis examiner, Indian Institute of Technology, Kanpur, 1979 and 1981.

Chaired peer review panel to review the Research program on "Microbial Degradation in Distribution Systems" for US EPA, June, 1983.

Member, State of Illinois Hazardous Waste Task Force, 1983.

5. Civic and Community Activities

Member, Board of Directors, IIT Alumni Association, 1981-present.

Alpha Epsilon Pi Fraternity
Regional Governor, 1978-present
National Scholarship Chairman, 1981-present.

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CAPABILTIES IN ENVIRONMENTAL AND HAZARDOUS WASTE ANALYSIS

INTRODUCTION

EXPERIENCE AND TECHNICAL CAPABILITIES

QUALITY ASSURANCE

by

Hazleton Raltech, Inc.
A Subsidiary of Hazleton Laboratories America, Inc.
3301 Kinsman Boulevard
Madison, Wisconsin 53704

I. INTRODUCTION

Hazleton Raltech, Inc., a subsidiary of Hazleton Laboratories America, Inc., is a scientific contract testing and research laboratory with diverse environmental testing capabilities designed to support government and industrial programs. With a staff of over 350 scientists and support personnel, the company has over 30 years experience in method development, problem solving, and high volume analysis. We maintain an extensive inventory of state-of-the-art instrumentation complemented by a computerized data system. The integrity of our data is ensured by our Quality Assurance Unit which, acting independently of the laboratories, monitors instrument operations and assay performance using an extensive file of established operating procedures.

Hazleton's analytical laboratories are experienced in and extensively qualified to conduct organic, inorganic, and gas chromatography-mass spectrometry (GC-MS) analyses of hazardous waste samples. Our most recent related projects, as detailed in subsequent sections of this document, have included environmental contamination surveys of an army ammunition plant and the area surrounding a large chemical manufacturing facility, and we are a collaborative laboratory for an EPA Effluent Guidelines contract. Successful participation in these and similar projects has been characterized by several key elements:

- Immediate response to crisis situations, stemming from an extensive equipment inventory, a rapidly mobilized staff, and a centrally located laboratory with 24-hour sample receiving.
- Extensive laboratory quality control programs which routinely include analysis of blanks, duplicates, and spikes, as well as a company-wide quality assurance program governing all laboratory activities.
- A carefully coordinated and monitored project organization, which draws together experts from appropriate disciplines to form a special team devoted to project needs.
- Customized data reporting in formats designed by the contractor.

In the following sections we have detailed our experience in and qualifications for conducting hazardous waste analyses.

II. EXPERIENCE AND TECHNICAL CAPABILITIES

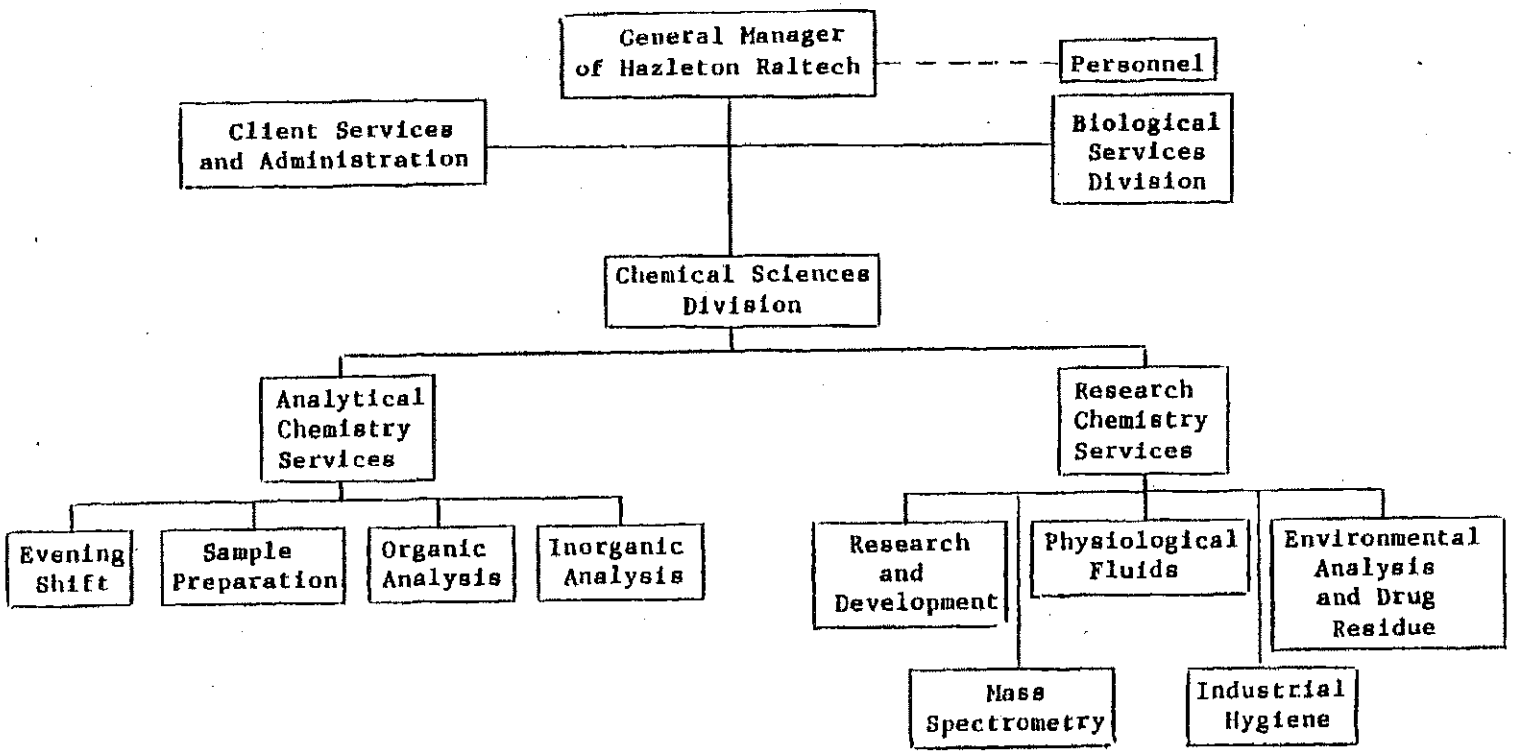
1. Departmental Organization and Capabilities

Hazleton's Chemical Sciences Division (Analytical and Research Chemistry Services) conducts about 25,000 assays per month. Sample matrices are diverse, and many well-established analytical procedures, using sophisticated instruments and techniques, are employed to detect analytes at microgram and submicrogram levels. The present organization, outlined in Figure 1, is directed toward generating rapid, accurate results. The organization is based upon several operating analytical departments, a computer-based monitoring system, a matrix management and multi-level monitoring, and a regular and broadly trained second shift operation.

Our senior staff have been involved for many years in managing demanding laboratory analyses and overseeing multi-discipline analytical projects. Collectively they have extensive experience in method development and sample analysis, and are accustomed to solving a wide range of problems such as adapting methods to new matrices, or increasing assay sensitivity and selectivity. Supporting the senior staff is a core of highly trained scientists and technicians who are specialists in their respective fields. In addition, our Sample Entry, Client Service, and Data Management Departments are staffed with personnel whose functions supplement the laboratory and maintain laboratory/client contacts.

Figure 1

Relationship of Analytical Laboratories
to Hazleton Raltech Organization



2. Facilities and Equipment

Hazleton's analytical laboratories cover approximately 225,000 square feet of working space which is designed to handle all types of chemical analyses while providing a safe and functional working environment. Separate rooms are provided for sample extraction and preparation, with refrigerator and freezer space in close proximity. Areas for hazardous activities are isolated from the primary laboratory and are clearly marked.

The Analytical Laboratories have a wide selection of sophisticated instrumentation in-house, including all types of chromatography and spectrophotometry equipment, mass spectrometers, and other major equipment. Many of the instruments in the laboratories are interfaced directly to computers which process and report data in various formats. Programs are available for statistical calculations of compiled data, and the staff statistician consults and assists scientists with data interpretation.

Following is a summary of our major analytical instrumentation. Because of the number of instruments available, sufficient backup exists in case of instrument failure or other unforeseen problems.

- Mass Spectrometers. Five individual systems, including a Finnigan 4021 T, a Varian MAT 112, and three Hewlett Packards. Capabilities include packed and capillary column inlets, dual electron impact-chemical ionization sources, and computerized mass spectral searching of the EPA/NIH mass spectral data base.

- Gas Chromatographs. Over 40 instruments, including Hewlett-Packards, Tracors, and Varians. Equipped with electron capture, flame ionization, thermal conductivity, nitrogen/phosphorous, and electrolytic conductivity detectors. Many instruments have dedicated data handling systems.

- Liquid Chromatographs. Waters Associates, Perkin Elmer, and Hewlett Packard models. Fixed and variable wavelength detectors and auto injection capabilities.

- Atomic Absorption Spectrometers. Perkin Elmer and Varian models with graphite furnace and autosampling capabilities.

- Ion Chromatograph. Dionex Model 2020I.

- Inductively Coupled Plasma Atomic Emission Spectrometer. Applied Research Laboratory model with automated split scanner and autosampling capabilities.

3. Laboratory Experience and Capabilities

Major Projects

- Environmental Survey of Joliet Army Ammunition Plant

  Hazleton provided sampling services and laboratory analyses as a subcontractor to Donohue and Associates in support of an environmental survey of the Joliet Army Ammunition Plant. Hazleton was inspected by personnel from USATHAMA and successfully performed certification analyses for explosive compounds, anions, and inorganics prior to field sample analysis. Over 200 water, soil, sediment, and fish samples were analyzed.

- Environmental Survey of A Major Chemical Company Site in California

  A project was conducted for a mmajor chemical company to determine the extent of contamination around an organic pesticide manufacturing site at Lathrop, California. Hazleton developed protocols and methods to analyze for organochlorine pesticides, organophosphate pesticides, phenoxy herbicides, fumigants, and other miscellaneous pesticides in soil, water, and animal tissue. In the development of these protocols specific storage conditions, extraction times, and analyses times were specified. A quality assurance program was employed which included analysis of blanks, spikes, and duplicates. Approximately 500 samples were submitted over an 8-month period. Each sample was analyzed for up to 40 different pesticides as described in the protocol. Reports were submitted to the client detailing the results, quality assurance data, problems encountered, possible solutions to problems, and detailed methodologies for each analysis.

- Environmental Survey of A Major Chemical Company Site in Michigan

  A project was conducted for a major chemical company to determine the extent of contamination surrounding an organic chemical plant in Montague, Michigan. For several years the waste from the plant had been placed in metal drums which were stacked in an adjacent field. The drums leaked waste into the soil and contaminated neighboring areas through runoff and groundwater leaching. Hazleton developed protocols and methods to analyze for volatile organic compounds, high boiling organic compounds, and pesticides in air, water, soil, fish, animal tissue, and vegetation.

As part of this project Hazleton developed new methods for determining volatile organics in fish, high boiling organics in tree bark, and pentac in deer tissue. Reports were submitted to the client detailing the results, quality assurance data, problems encountered, possible solutions to problems, and detailed methodologies for each analysis.

- PCB Distribution in a Landfill Site

A project was conducted for a client to determine the distribution of PCB in a landfill site. Prior to analyzing approximately 500 samples of soils and sediment for moisture and PCB content, protocols were developed. The protocols defined the chain of custody procedures, storage, sample preparation, quality assurance procedure, and methods of analysis. The analytical method was validated using a prepared spiked soil sample which was analyzed 16 times on four different days, and blind check samples submitted by the client.

A computer report format was designed to meet the client needs of sample identification, sampling date, extraction date, analysis date, and the results of the analyses on a wet weight and dry weight basis.

- EPA Contract

Hazleton is currently under contract (68-01-5978) with the Effluent Guidelines Division of the Environmental Protection Agency (EPA). This contract is part of an analytical verification study to prepare and analyze effluent water samples from a wide variety of industries by gas chromatographic analyses with mass spectrometric confirmation, and to inject and analyze prepared extracts by gas chromatography and gas chromatography-mass spectrometry. Our contract primarily concerns compliance monitoring of industrial effluents. We have analyzed over 10,000 fractions or extracts of water samples using gas chromatographic techniques and have injected and analyzed over 1,300 prepared extracts by gas chromatography and 3,000 prepared extracts by gas chromatography-mass spectrometry. We currently analyze per month approximately 150 volatile and 600 semi-volatile fractions by gas chromatography and up to 200 prepared extracts by gas chromatography or gas chromatography-mass spectrometry for quality assurance or confirmation purposes.

- Multi-Element Analyses by ICP

Our work with inductively coupled plasma-optical emission spectrometry (ICP-OES) as a multi-element analysis technique is extensive and has been used increasingly for client projects and

routine analyses. We have developed methods utilizing ICP-OES for analyzing many diverse matrices such as biological and plant tissues, physiological fluids, food products, minerals, industrial wastewaters, and solid wastes. The work with these matrices has involved quantitating both major and trace elements. A presentation of some of this work was made at the 1979 Pittsburgh Conference and the AOAC Spring Workshop in St. Louis, Missouri in 1980 regarding the problems associated with analyzing many of these matrices for toxic trace elements (heavy metals) and our application of ICP-OES to this task. Our most recent work was developing a heavy metals screen involving a preliminary preparation step before analysis by ICP-OES. This technique circumvents some of the interferences normally encountered when analyzing diverse matrices and provides a cost effective multi-element scan for toxic trace elements.

Other Project Experience

- A project was conducted for a food manufacturing client to determine the extent of PCB contamination in packaging material and the transfer of PCB to the product. Packaging material was submitted to Hazleton for PCB analysis and to determine if the material was acceptable for packaging. This required a fast turnaround to allow for production to continue. Approximately 300 samples of packaging material were prepared and analyzed over a 2-3 month period with a turnaround time of 2-3 days for groups of samples (averaging 20-30 samples per group). Quality control procedures were used which included the analysis of spikes, duplicates, and blanks.

  Protocols were developed and experiments were designed to determine the amount of PCB translocation or migration from the packaging material to the product. These experiments were conducted over a 9-month period under various packaging and storage conditions. Analyses of PCB in the packaging material and the product were performed over the period of the experiment.

- A project was conducted for a client to determine the distribution of PCB in a landfill site. Prior to analyzing approximatley 500 samples of soils and sediment for moisture and PCB content, protocols were developed. The protocols defined the chain of custody procedures, storage, sample preparation, quality assurance procedure, and methods of analysis. The analytical method was validated using a prepared spiked soil sample which was analyzed 16 times on four different days, and blind check samples submitted by the client.

  A computer report format was designed to meet the client needs of sample identification, sampling date, extraction date, analysis date, and the results of the analyses on a wet weight and dry weight basis.

4. Laboratory Information Management System

An essential component of Hazleton's support system is the computer-based Laboratory Information Management System (LIMS). The current LIMS used by Hazleton has been in continuous use for 10 years and represents the result of over 25 man-years of effort. During its 10 years of operation, the system constantly has been improved to its present status of the most comprehensive computerized system used by a contract testing laboratory.

The use of a single data base as the repository of all laboratory data ensures that a minimum of effort is expended in recording the data and that, once entered, any data are accessible to all levels of the laboratory instantaneously. Data transcription is eliminated and the errors associated with that function are minimized. The basic LIMS programs enable the user to log samples on the system, generate worksheets, report finished results to the system, generate printed reports on finished samples, and generate various management reports.

The hardware configuration of the host is a pair of IBM 370/3033 computers linked in tandem, each with 8 megabytes of main storage. A corporate data processing group supports the system software in conjunction with IBM. Special features of the system include the following:

- System Security

  All access to the host is both location and password protected. Location security ensures that only designated terminals on the telecommunications network will have access to the LIMS software. Additionally, the prospective user must verify his identification by entering his personal password. Users are required to change their password every 30 days or they are denied access to the system. Thus, the client is ensured that all sample data, as well as any other client-related information, are kept completely confidential.

- Backup Procedures

  All of the LIMS data bases supported by the host are copied twice a week and stored at both the computer site and at a secure off-site location to guard against a local site disaster. The corporation has an active Disaster Recovery Team composed of representatives from each of the operating divisions. This team's reponsibility is to ensure successful recovery of the corporate mainframe if possible, or to coordinate the use of an off-site computer to restore critical data processing functions.

- Management Reports

  On a monthly basis LIMS generates a management report detailing laboratory workloads and service time. Minor programming will enable automatic calculation of residence and turnaround time for all samples as defined in the RFP.

In addition to the LIMS system, Hazleton has many computers in the laboratories which are interfaced directly to the instrumentation. For example, the mass spectrometers have dedicated computer systems which automatically conduct mass spectral comparisons of sample mass spectra to standards in the EPA/NIH Mass Spectral Data Base. Many of the gas and high performance liquid chromatographs also have dedicated computer systems, thus allowing rapid data tabulation in client-designed formats.

III. QUALITY ASSURANCE

Hazleton's quality assurance program consists of key segments:

- Documented procedures for daily operation of the laboratories.
- Inspection and review of all activities related to this project by an independent Quality Assurance Unit.

A comprehensive quality assurance/quality control (QA/QC) program is coordinated by a Quality Assurance Unit (QAU) consisting of five full-time persons, two degreed chemists, two degreed biologists and one administrative assistants. This unit is independent of all operating departments and reports directly to the President of Hazleton.

The QAU reviews, approves, and distributes all technical and administrative methods and procedures used in project and assay work. These written methods and standard operating procedures, including an outdated file, are part of the official Hazleton records.

Over 1000 standard operating procedures and 800 method procedures provide standardization and control for Hazleton's daily activities. These, along with the project protocol, are the references for the QA in-progress inspection of the assays and projects done by the laboratory. A minimum of two inspections per day take place throughout the laboratory. Examples of typical items inspected include:

- Chemical assay procedures and validation.
- Reagent preparation and labeling.
- Controls and standards.
- Instrument calibration and maintenance.
- Results of analyses.
- Data recording and analysis.
- Archiving of data.
- Training documentation and personnel qualifications.

The QAU keeps a master inspection schedule, prepared at least 30 days in advance, giving the date of inspection, and the project phase and/or assay to be inspected. Inspection reports are issued to management for all inspections and are kept on file by the QAU. Adverse findings are addressed by the study director and/or management. The QAU inspection records are kept separately for every study and are available to management and the sponsor.

Data audits and final report reviews are also part of the QAU inspection program. Hazleton encourages sponsor visits to audit data and inspect ongoing studies.

Examples of procedures that are required for daily operation include:

- Instruments and Equipment. Every instrument and piece of equipment has an Instrument Operating Procedure (IOP) that details use, calibration, and maintenance. These IOPs are kept next to each instrument as well as in the departmental files, and in the QAU office with the entire master file. The QAU inspects the use of instruments and the adherence to the IOPs as part of the regular inspection activities.

- Reagents. All reagents are labeled according to a General Operating Procedure (GOP) This requires labeling of name, concentration, expiration date, storage condition, date of preparation, and the person who prepared it. The QAU also includes reagents in its inspection program.

- Method Validation. All quantitative methods used at Hazleton are validated using analytes in matrices that are similar to the unknowns to be analyzed. Sixteen samples are analyzed initially, as well as spikes at one and two times the expected concentration. The standard deviations then are calculated. The statistical analysis of method validation data provides guidelines for acceptance or rejection of data generated by the analysis of field samples.

The success of any Quality Assurance Program is dependent upon complete documentation and regular inspections. Hazleton's independent QAU inspects all phases of a project and makes the inspection reports available to the client upon request. Also, all documentation related to the project is available for client review.

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October 13, 1983

Mr. Thomas Borecki, Engineer
Environmental Control Division
Offices of the Attorney General
160 North La Salle, Room 900
Chicago IL 60601

Dear Mr. Borecki:

In response to your request, I am enclosing a proposal for bench-scale testing of processes for detoxification of cyanide-contaminated film chips. As outlined in the proposal, we would perform the work in phases and would consult with you or your staff upon completion of each phase. We estimate that we could complete the testing program approximately 4 weeks after initiation.

The estimated cost of the entire project is $16,800. We anticipate that research and development aspects of the project will require 156 hours of effort, billed at $75/hour, for a total of $11,700. In addition, we estimate that the following routine analyses will be required: cyanide (24 samples), cyanide amenable to chlorination (24 samples), ICP spectroscopy (24 samples), silver (24 samples), mercury (24 samples), and cyanate (18 samples). The total cost of these routine analyses would be $5,100.

Please feel free to contact me if you have any questions about the proposal.

Sincerely,

Leon W LeVan

Leon W. LeVan, PhD
Research and Development

LWL/km

Enclosure

cc: E. Sturino
Central File

(3727B)

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PROPOSAL

Bench-Scale Testing of Detoxification of Cyanide-Contaminated Film Chips

for

Environmental Control Division
Office of Attorney General, State of Illinois

by

Hazleton Laboratories America, Inc.
Chemical & BioMedical Sciences Division
3301 Kinsman Boulevard
Madison, Wisconsin 53704

October 13, 1983

INTRODUCTION

Hazleton Laboratories America, Inc. (HLA) will undertake bench-scale testing of a wet chemical process for detoxification of cyanide-contaminated film chips. The project will be conducted in four successive phases:

- Characterization of Starting Film Chips.
- Dewatering Characteristics of Soaked Chips.
- Efficiency of Cyanide Removal.
- Efficiency of Cyanide Destruction.

Sample preparation will be performed by the Research and Development Group. Analyses for cyanide and cyanate will be conducted by the Environmental Analysis Group, and metals analyses will be conducted by the Inorganic Analysis Group. In the following sections we describe a specific plan of action, including experimental procedures and analytical methods. The work plan is followed by the anticipated project schedule.

Phase I. Characterization of Starting Film Chips

Representative batches of cyanide-contaminated film chips will be supplied by the Client. Each batch submitted for characterization should consist of at least 500 g of film chips (dry or drained wet weight). HLA will perform the following analyses on each batch of chips:

- Cyanide

  Both total cyanide and cyanides amenable to chlorination will be determined. Methods employing distillation will be used to ensure liberation of cyanide from the film matrix and to eliminate the possibility of interferences from organonitrogen constituents present in the film emulsion.

  Total cyanide will be determined by Standard Method 412B (Total Cyanide After Distillation) and cyanides amenable to chlorination will be analyzed by Standard Method 412F (Cyanide Amenable to Chlorination After Distillation). In addition, semiquantitative spot tests (e.g., Standard Method 412I) may be used for initial sample screening to allow estimation of appropriate sample weights and dilution factors for use in the distillation methods.

- Cyanate

  Analytical methods for cyanate rely on measurement of cyanate in aqueous solution and so are not directly applicable to a solid sample matrix. Therefore, cyanate analysis will be performed on a water extract of the film chips. A 50-g sample of film chips will be stirred in four successive changes of deionized water (100-mL portions). The water extracts then will be combined in a flask containing 100 mL of 1N sodium hydroxide as a stabilizer. The alkaline pooled water extract will be analyzed for cyanate using Standard Method 412J (Cyanates).

The detection limit for cyanate in water using Method 412J is 1-2 mg/L (ppm). If 100% recovery of water-soluble cyanate from the chips is assumed, the scheme outlined above would give a detection limit of 20 ppm in the film chips.

- Metals

The following elements will be determined by ICAP spectroscopy:

Calcium	Aluminum	Copper
Phosphous	Barium	Zinc
Potassium	Iron	Manganese
Sodium	Strontium	Chromium
Magnesium	Boron	

All of these elements are determined simultaneously in a single analytical procedure which involves digestion of the sample and dissolution of the residue. Water samples will be analyzed directly. Attachment 1 describes the methods's capabilities.

Silver will be determined by atomic absorption spectroscopy.

Mercury will be determined by flameless atomic absorption sepctroscopy.

Phase II. Dewatering Characteristics of Soaked Chips

Representative batches of film chips will be dried in a vacuum oven and weighed samples of the dry chips will be soaked overnight in deionized water to ensure complete water regain. The resulting soaked chips will be dewatered by gravity draining on a 1/16-in. stainless steel screen. After draining, the weights of the dewatered chips and the recovered water will be determined, and the dewatering characteristics (e.g., water content) attained by gravity draining will be calculated.

Phase III. Efficiency of Cyanide Removal

In this phase we will examine the effects of caustic washes on removal of cyanide from the film chips.

Initially we will perform an experiment to determine the physical effects of caustic washes (ambient and elevated temperatures) on the film material. Representative batches of the film chips will be subjected to the following treatments.

- Caustic concentration: 0.01N, 0.1N, and 1N sodium hydroxide solutions.
- Temperature: ambient, 40°C, and 60°C

Each treatment (nine total) will be conducted for 2 hours in a magnetically stirred vessel. The effect of the caustic treatment on the film material will be evaluated subjectively. Our goal in this experiment is to establish conditions of time, temperature, and alkali concentration which will result in complete removal of the film emulsion without degradation of the underlying plastic film base. Since the film base is impervious to water and so presumably contains no cyanide, removal of the emulsion layer should give nearly total removal of the cyanide contamination.

In the subsequent experiment to study the efficiency of cyanide removal, a representative batch (50 g) of film chips will be treated using a set of conditions (established above) which gives complete removal of the film emulsion layer. The volume of the caustic wash solution will be 500 mL. After the caustic treatment, the treated chips will be drained on a stainless steel screen, washed with deionized water (500 mL), and drained again. The combined caustic wash and water wash then will be analyzed for cyanide (total and amenable to chlorination), cyanate, and metals with the analytical method described in Phase I. The dewatered chips also will be analyzed for cyanide, cyanate, and metals as described for Phase I. Depending on the results of the cyanide analysis, the experiment may be repeated with more severe conditions. Our intent is to establish conditions for most efficient removal of cyanide from the chips.

Phase IV. Efficiency of Cyanide Destruction

The caustic wash from Phase III containing the highest cyanide concentration will be used for tests of cyanide destruction efficiency. All tests of cyanide destruction will be performed in stirred vessels at ambient temperature. Aliquots (200 mL) of the caustic wash will be treated with sufficient aqueous sodium hypochlorite to give final hypochlorite concentrations of 1%, 5%, and 10%. Reaction times of 1/2, 1, and 2 hours will be used.

At the desired sampling times aliquots of the treated wash water will be removed and the pH and oxidation/reduction potential will be measured. The samples then will be treated with sodium thiosulfate (to destroy excess hypochlorite), followed by sufficent sodium hydroxide to achieve pH $\geq$ 12 (to ensure storage stability). Stabilized samples will be stored in the dark at 4°C until analysis. The analyses for cyanide and metals will be conducted as described for Phase I. In addition, total suspended solids will be determined by gravimetric analysis.

PROJECT SCHEDULE

We anticipate that the program outlined above could be completed in 4 weeks following receipt of test material from the Client. The timetable for the project is outlined below.

Phases I and II will be conducted concurrently. The estimated time for completion of both phases is 1 week (based on analysis of five batches of chips). Upon completion of Phases I and II the results will be discussed with the Client. At this time an appropriate test material (specific batch of film chips or composite sample) will be chosen for use in Phases III and IV.

Estimated time for completion of Phase III is 1 week. During this phase the Client will be informed as to the results of the cyanide removal experiments, and a decision will be made as to the acceptability of the cyanide removal procedure before Phase IV is initiated.

The estimated time for completion of Phase IV is 1 week. We estimate that an additional week then would be required to complete any remaining analyses, perform data analysis, and issue a final project report.

While we believe the timetable outlined above is realistic, additional time would be required if unacticipated difficulties are encountered. The main technical problem which may arise would be interference of the film emulsion or cyanide wash constituents in the cyanide and cyanate analytical procedures. Any difficulties encountered which would result in deviation from the projected schedule would be promptly communicated to the Client.

Attachment 1

ICP SPECTROSCOPY

Lowest Confidence Levels
(Parts Per Million)

	Plant Tissue	Food Products	Water	Soils & Sludges	Water (Concentrated)
Calcium	2.5	0.5	0.1	10	0.01
Phosphorus	12.5	2.5	0.5	50	0.05
Potassium	7,500	1,500	300	30,000	30
Sodium	750	150	30	3,000	3.0
Magnesium	12.5	2.5	0.5	50	0.05
Aluminum	5.0	1.0	0.2	20	0.02
Barium	0.25	0.05	0.01	1.0	0.001
Iron	0.25	0.05	0.01	1.0	0.001
Strontium	0.125	0.025	0.005	0.5	0.0005
Boron	1.0	0.2	0.04	4.0	0.004
Copper	1.25	0.25	0.05	5.0	0.005
Zinc	0.25	0.05	0.01	1.0	0.001
Manganese	0.25	0.05	0.01	1.0	0.001
Chromium	0.75	0.15	0.03	3.0	0.003

Plant Tissue: Levels based on digesting 2 g of sample with a final volume of 50 mL.

Food Products: Levels based on digesting 10 g of sample with a final volume of 50 mL.

Water: Levels based on digesting 50 mL of sample with a final volume of 50 mL.

Soils & Sludges: Levels based on digesting 1.0 g of sample with a final volume of 100 mL.

Water (Conc.): Levels based on digesting 250 mL of sample with a final volume of 25 mL.

Attachment 1 (Continued)

Lowest Reporting Limits for ICP Spectroscopy - General Guidelines

	(mg/100 g)		
	Dry Products, Cheese, etc.	Meats, etc.	Juice, Milk, etc.
Ca	0.1	0.05	0.025
P	0.5	0.25	0.13
K	300	150	75
Na	30	15	7.5
Mg	0.5	0.25	0.13
Al	0.2	0.1	0.05
Ba	0.01	0.005	0.0025
Fe	0.01	0.005	0.0025
Sr	0.005	0.0025	0.0013
B	0.04	0.02	0.01
Cu	0.05	0.025	0.013
Zn	0.01	0.005	0.0025
Mn	0.01	0.005	0.0025
Cr	0.03	0.015	0.0075

ATTACHMENT 2

Method References

Standard Methods 412B, 412F, 412I, and 412J:

Standard Methods for the Examination of Water and Wastewater, 15th Edition (1980).

IIT Research Institute
10 West 35 Street, Chicago, Illinois 60616
312 567-4000

October 14, 1983

State of Illinois
Attorney General's Office
160 North LaSalle
Chicago, IL 60691

Attention: Howard Chinn

Subject: IITRI Proposal No. 83-466C
"Film Chips Treatability Study"

Gentlemen:

The purpose of this letter is to outline an experimental program designed to resolve some of the questions concerning the efficacy of chemical treatment methods for removing cyanide from the film chips. A series of bench-scale experiments and analytical work are proposed. The objective of these experiments is to provide guidance in assessing the feasibility of chemical treatment, not to provide a basis for scaling up a particular treatment process. The provision of the representative sample is crucial for assessing any potential chemical treatment and the results of any experimental work are contingent upon this.

BACKGROUND

In the manufacture of film, an emulsion layer is deposited onto an inert support material. Earlier support materials consisted of cellulose triacetate and have since been replaced by polyester (polyethylene terephthalate), the latter preferred due to its greater dimensional stability. On the support material, a coating is frequently applied to make the emulsion spread more evenly. The gel emulsion is prepared by mixing together a solution of silver nitrate with a halide. In X-ray film, this halide is normally bromide. The mixture of the two causes the precipitation of silver bromide crystals which are then adsorbed onto a colloid. Gelatin is frequently used as the colloid because it promotes the separation of the crystals and does not inhibit grain

growth. The grains are allowed to grow (ripen) to the desired crystal characteristics. Sensitizers are added to the gel emulsion and it is then coated onto the film support. The gelatin is stable, keeps the silver halides on the film support, and permeable in order to allow the penetration of the film processing chemicals. Hardening agents reduce the tendency of the gelatin to softening and swelling and are added to increase the film's resistance to high-temperature processing, highly alkaline solutions and surface abrasion during processing. Metallic salts, such as chrome alum, are frequently used as hardening agents. Stabilizers are also added to reduce the desensitization of the film during storage.

In the silver recovery process, the shredded film fragments were treated with a sodium cyanide solution to complex the silver as silver cyanide. The structure of silver cyanide complexes is linear and may be polymeric with infinite chains. $AgCN_2$ has a stability constant,* β_2 of $10^{20.8}$. Thus, the complex does not dissociate readily and is therefore amenable to electrolytic recovery. The metallic cyanide compounds that may possibly be present in the film chips in a major amounts include ferric cyanide, from the corrosion of the trailers. Other metals in smaller quantities that may be present in the film chips and may form complexes with cyanide include zinc, copper, and chromium. These metals probably originated with the film. Metal cyanides generally are not easily dissociated, but with an excess of oxidant and the proper reaction conditions, some can be oxidized (with the exception of ferric cyanide). Ferric cyanide is a very stable, soluble compound with a β_6 of 10^{31}. Two different types of bonding are involved that contribute to the unusually high stability of the compound. It is likely that this compound will not be oxidized under any but extreme conditions.

Thus, there are two problems that have to be addressed in the chemical removal of cyanide from the film chips, first, the likelihood of cyanide permeation and retention in the gel emulsion layer, and second, the presence of cyanide complexes not amenable to oxidation. A more detailed analysis of the film chips is necessary to determine which is more predominate. A major

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* $\beta_n = \dfrac{[ML_n]}{[M]\,[L]^n}$ M = Metal, L = Ligand

problem is the heterogeneity of the film chips and their variation from site to site. If there is a considerable amount of iron contamination in all of the locations of the film chips, an aqueous chemical treatment method will probably, under proper conditions, get the cyanide into solutions, however, oxidation of the ferric cyanide in solution may be impossible. However, if the ferric cyanide concentration is slight in comparison to the other forms of cyanide, it may be diluted in the process to concentrations acceptable for sewer discharge. If the cyanide is trapped in the gel emulsion layer, it may be possible to remove the gelatin by a simple hot, alkaline wash. Clearly, more analytical work is necessary to resolve these questions.

STATEMENT OF WORK

The experimental work will be conducted in two tasks; methods of removing the gel emulsion layers and determination of oxidizable cyanide. These tasks will be outlined in the following section.

Task 1. Methods of Removing the Gel Emulsion Layer

In these experiments, samples of the film chips will be subjected to various conditions in an attempt to remove the emulsion layer. Film chips taken from one site only will be tested. Exposing the film chips to hot water, with agitation, will be evaluated. All experiments will be done in 500 ml glass beakers using a bench-top paddle blade stirrer. Alkaline conditions will be used to mitigate the evolution of hydrogen cyanide. An analysis of the film chips for cyanide, silver, iron, zinc, copper, and chromium will be done initially. Solution concentrations of cyanide and metals will be monitored and compared to solution concentrations of similarly treated (pH, agitation) film chips at ambient temperature conditions. The conditions of pH 9, 11, and 13 will be tested for water temperatures of 140, 180, and 200°F for residence times of two hours, 30 minutes, and 15 minutes. This represents 27 different bench scale tests, not including additional tests for narrowing down the optimum temperature, residence, and pH conditions. All conditions of the test will be noted, i.e., caustic consumption, agitation speeds, etc. The supernatant will be filtered in each case and the mass of suspended solids produced per mass of film chips will be noted.

Both total cyanide and cyanide amenable to chlorination in the supernatant will be tested, as per "Standard Methods". The metals will be

done using a Jarrel-Ash Inductively Coupled Argon Plasma System 9000A, which has the advantage of determining a number of metals from one sample.

Task 2. Determination of Oxidizable Cyanide

The results from the first task will be helpful in guiding the Task 2 experiments. Sodium hypochlorite dosages will be estimated based on the amenable chlorine concentration determined in Task 1. Two different methods of adding the oxidant to the film chips will be evaluated, addition of a hot sodium hypochlorite solution at the optimum temperature and pH conditions determined in Task 1, and addition of sodium hypochlorite to the filtered supernatant from the hot caustic rinse. In the first method of adding the sodium hypochlorite solution, a sample of the dry film chips will be exposed to an estimated amount of sodium hypochlorite. The film chips/hypochlorite will be brought to the optimum pH and temperature conditions and allowed to react for a specified time. The suspension will be agitated throughout the reaction time. After settling, the total cyanide, cyanide amenable to chlorination and cyanate concentration of the supernatant will be measured. This will be compared with the cyanide concentration of the film chips (found in the initial characterization). The oxidation/reduction potential will be monitored during this reaction. In the second method of adding the hypochlorite, hypochlorite will be added to the supernatant generated from the hot water rinse step. The supernatant solids will normally be filtered before the addition of the hypochlorite, however, one or two sets of experiments will be done without removing these solids to get an idea of the amount of reagent consumption created by the suspended solids. By adding the hypochlorite in two different ways, the ability of chlorine to oxidize the cyanide in liquid and solid phases will be assessed. Optimum reaction times will be determined and all conditions of the experiments will be noted.

CLOSURE

The proposed research effort represents a one month effort. Work can begin immediately upon receipt of the research agreement. The cost for this work is $18,850 beyond which costs will not be incurred without the client's specific approval.

We are enclosing two copies of our Research Agreement executed on behalf of IIT Research Institute. To initiate the program, please return one [1) fully executed agreement to IITRI. If you have any questions regarding the agreement, please contact Mr. R. F. Hoffmann, Administrative Supervisor at 312/567-4306.

We are pleased to have this opportunity to submit this proposal to you. We look forward to working with you in the future.

Respectfully submitted,
IIT RESEARCH INSTITUTE

Mary L. Schurger
Associate Engineer
Chemical Engineering Research

Approved by

Morton J. Klein
Vice President
Research Operations

MLS/bf

REFERENCES

1. Basolo, F., Johnson, R., "Coordination Chemistry", W. A. Benjamin, Inc., New York, NY (1964).

2. Cotton, F. A., Wilkinson, G., Advanced Inorganic Chemistry, A Comprehensive Text, Interscience Pub., John Wiley & Sons (1967).

3. Kirk-Othmer Encyclopedia of Chemical Technology, 2nd Ed. (1966).

4. Sillen, L. G., Martell, A. E., "Stability Constants of Metal-Ion Complexes", The Chemical Society, London (1964).

5. Standard Methods for the Examination of Water and Wastewater, 14th Ed., APHA, AWWA, WPCF (1976).

6. Eaton, G. T., Photographic Chemistry in Black and White and Color Photography, Morgan & Morgan, Inc., Hasting-On-Hudson, NY (1965).

IITRI

IIT Research Institute

RESEARCH AGREEMENT

RESEARCH AGREEMENT

For the purpose of promoting the increase of useful knowledge, IIT RESEARCH INSTITUTE, a not for profit corporation of the State of Illinois, organized and operated for scientific and educational purposes (hereinafter referred to as "IITRI"), having its office and place of business in Chicago, Illinois, proposes on behalf of

Office of Illinois Attorney General

(hereinafter referred to as "Client") having an office and place of business in Chicago, IL., to conduct research and development investigations (hereinafter referred to as "the Project"), relating to "Film Chips Treatability Study"substantially in accordance with IITRI's Letter Proposal No. 83-466C dated October 14, 1983, said proposal hereby being made a part hereof by reference.

This proposal is effective until December 17, 1983, and, if accepted by Client on or before that date in the place provided for that purpose at the end of this Agreement and delivered to IITRI, will become a contract between the parties, upon the following terms and conditions:

I. PROJECT AND RESEARCH FUND

Client requests IITRI to carry out the Project for a period of one (1) months commencing on the date IITRI first assigns personnel to the Project. Client agrees to pay IITRI for its services hereunder a total sum up to but not to exceed

EIGHTEEN THOUSAND EIGHT HUNDRED FIFTY---------- Dollars ($ 18,850.);

and IITRI shall not expend more than said sum without first securing the written approval of Client. IITRI agrees to undertake, and to endeavor in good faith successfully to complete, the Project as provided in this Agreement.

II. CHARGES

For IITRI's services hereunder Client will be charged an amount equal to the compensation paid by IITRI to the members of its technical staff assigned to the Project for work on the Project (part time services being prorated), plus an overhead charge to cover the cost of IITRI's general facilities, equipment and administrative expenses, and plus also the cost, at established rates, of work performed in IITRI's service shops especially for the Project, as well as the cost of special supplies required for the Project, and traveling and other miscellaneous expenses pertaining thereto, subject, however, to the limitation that the entire amount charged to the Project during the term of the Project shall not, without the written approval of Client, in any event exceed the amount hereinbefore specified in Article I.

III. ADDITIONAL EQUIPMENT

If equipment not already owned by IITRI and available for the Project shall be required, such additional equipment shall, with the approval of Client, be built or purchased by IITRI and the cost thereof shall be paid by Client. Such additional equipment shall be

the property of Client, but title shall pass to IITRI unless Client shall, within thirty (30) days after completion of the Project or the termination of this Agreement, request delivery of said additional equipment, in which event it shall be shipped to Client, but the cost of packing and shipping, and also all expenses incidental thereto, shall be borne by, and upon request paid in advance, by Client.

IV. PAYMENT

Invoices will be presented monthly, and will cover actual charges incurred on the Project during the preceding month. Client agrees to pay the invoices of IITRI within thirty days after receipt, and IITRI reserves the right to discontinue the Project if Client fails to pay any of the invoices within the time specified.

V. ADVISORY COMMITTEE

To provide a medium through which the parties may establish effective communications and coordinate their work on the Project, an advisory or steering committee shall be established consisting of representatives (not more than three, unless IITRI shall otherwise agree), appointed by Client, and an equal number of IITRI staff members. The Committee shall meet at times to be agreed upon for the purpose of determining the general course of the Project, reviewing its progress, and providing such other assistance as IITRI shall deem advisable to enable it to conduct the Project to the best advantage of Client.

VI. REPORTS

IITRI agrees to render to Client at predetermined periods written reports, in duplicate, of its findings and progress made during the term of the Project.

VII. PATENTS

Any and all patentable inventions relating to the subject matter of the Project which hereafter may be made by staff members of IITRI assigned by IITRI to the Project, during the time they are performing work on the Project and as a result thereof, as well as any and all patent applications and patents disclosing said inventions, shall become the property of Client, subject to the terms and conditions of this Agreement. IITRI has required and will require each of its technical staff members to execute and deliver to IITRI an agreement to assign to IITRI any and all inventions covered by this Agreement; and IITRI agrees to assign its interests in said inventions to Client. IITRI shall keep memoranda in writing, including notes on experimental and research work, descriptions, diagrams and other data pertaining to any and all inventions covered by this Agreement, all of which shall be available at reasonable times to Client.

VIII. CONFIDENTIAL INFORMATION

It is understood that IITRI will endeavor in good faith to keep confidential, and disclose to no one without the consent of Client, * provided, however, that nothing shall be deemed secret or confidential which is described in any prior printed publication or patent, or is a matter of public record.

* information relating to the Project, including but not limited to any correspondence, reports, laboratory analyses, and any other documents ("Confidential Information"),

IX. PUBLICATION BY CLIENT

Client agrees to submit to IITRI all advertising, sales promotion, and other publicity matter relating to the Project wherein the name of IITRI is mentioned or language is used from which the connection of IITRI therewith may, in the judgment of IITRI, be inferred or implied; and Client shall not, without the prior written approval of the Director of IITRI, publish or use such advertising, sales promotion, or publicity matter. Client further agrees that it will not publish the results of the Project without the prior written approval of the Director of IITRI; provided, however, that such approval will not be unreasonably withheld in connection with the publishing of reports for the use of Client's present clients.

X. CONFLICTING PROJECTS

IITRI agrees that it will not, during the term of this Agreement, knowingly undertake any other investigation which, in its opinion, conflicts with the Project, and Client agrees that IITRI will not be required to undertake under this Project work which conflicts with any other program at IITRI.

XI. TERMINATION

If the maximum amount agreed by Client to be paid hereunder as provided in Article I is expended prior to the expiration of this Agreement, this Agreement shall terminate unless prior to such termination Client and IITRI shall in writing agree to an extension thereof on mutually satisfactory terms. Client may terminate this Agreement at any time upon thirty (30) days written notice to IITRI.

XII. NONLIABILITY IN CERTAIN EVENTS

Neither party shall be liable in any way for failure to observe or perform any provision of this Agreement if such failure shall be caused by any law, rule, or regulation of any constituted public authority or shall be due to any cause beyond the control of the party in default.

IIT RESEARCH INSTITUTE

By _____

Its Business Manager
T. R. Plonis

October 17, 1983

ACCEPTED:
OFFICE OF ILLINOIS ATTORNEY GENERAL

By _____

Its

Dated _____, 19____